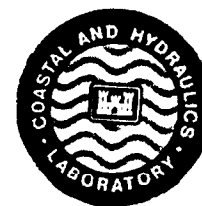




Coastal Engineering Technical Note



Near-Real-Time Coastal Monitoring

By Margaret A. Sabol

PURPOSE

The objective of this Coastal Engineering Technical Note is to describe the Near-Real-Time (NRT) coastal data acquisition and processing capabilities that have been developed by the Prototype Measurement and Analysis Branch (PMAB) of the Coastal and Hydraulics Laboratory. These capabilities aid in data quality control and provide internally recorded and NRT wave, water-level, and current data products to Corps of Engineers (CE) sponsors. CE open-coast, inlet, and harbor projects utilize the Prototype Measurement Analysis System (PMAS) for monitoring in support of design and operational engineering tasks. PMAS consists of coastal oceanographic sensors and instrumentation, communication equipment, and a relational database management system (McKinney and Howell 1996). Figure 1 is a schematic representation of PMAS. In the figure, solid lines represent NRT data access. The term "sensors" may refer to NRT directional wave gauges (DWG-1s) (Howell 1992, 1993) or single pressure sensors. The term "RTU" refers to a Remote Transmission Unit, which consists of the following:

- a. An all-weather, protective housing.
- b. Cable connections linking an RTU to sensors for transferring data into the RTU.
- c. Data storage hardware and software; and telecommunication hardware and software.
- d. Transferring data out of the RTU (via radio or telephone line).

The Automated Real Time Tidal Elevation System (ARTTES) provides offshore water level information to survey vessels and dredges using direct measurements coupled to a predictor-corrector processing program (Lillycrop et al. 1991). The dashed lines going to NOAA/NDBC (National Oceanographic and Atmospheric Administration / National Data Buoy Center) and DWG-1s indicate that data are received and inserted into PMAS but not in NRT mode. Data from NOAA/NDBC are received monthly. Data from internal recording DWG-1s may be collected quarterly to yearly, depending on the requirements of the project. This technical note will summarize the NRT data products and how PMAS is used to provide them.

SITES AND PARAMETERS

Within the past year, PMAB has monitored approximately 63 sensors at 12 CE projects in an NRT mode as well as another 8 sensors in an internally recorded mode. PMAB's computer calls the NRT sites around the clock, 7 days a week to transfer data. This translates to over

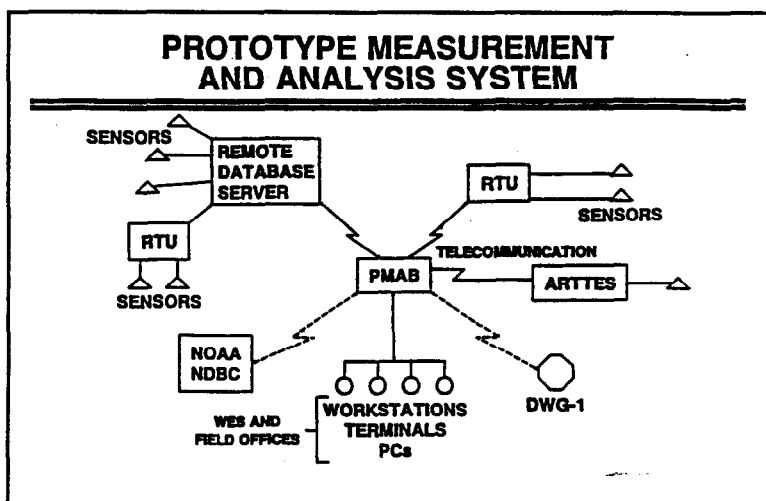


Figure 1. Prototype Measurement and Analysis System

3,200 data records received weekly from NRT systems. Table 1 lists the automatically accessed remote sites that have been active this year. In addition to this year's active sites, PMAB has been responsible for data collection in NRT mode at Sarasota, FL; the first rapidly installed breakwater systems (RIBS) deployments at Currituck Sound, NC; Dewey Beach, DE; and Lanai, HI. Historical sites using internal recording gauges include Galveston, TX; Coney Island, NY; Barnegat Bay, NJ; a second RIBS deployment at Pensacola, FL; Cape Fear, NC; Redondo, CA; Yaquina, OR; and Virginia Beach, VA.

Routine monitoring is performed to record data for the following parameters:

- a. Nondirectional and directional wave height, period, direction, and energy spectra of nearshore, wind waves.
- b. Water levels and tides in harbors and bays.
- c. Long-period wave energy in harbors.
- d. Tidal inlet currents and water levels.

While these are the parameters most often requested, PMAS has been designed to allow for the addition of various other parameters as required.

| Table 1 Automatically Accessed Remote Sites | | | |
|---|-----------------------------|--------------------|--|
| Connection | Project Site | Monitoring Systems | Sensors |
| (1) RTU | Chicago, IL | 1 | 3 pressure |
| (1) RTU | Long Branch, NJ | 1 | 3 pressure |
| (1) RTU | Sandy Hook, NJ | 1 | 3 pressure |
| (2) RTU | Ocean City, MD | 4 | 6 pressure 1 barometer |
| (1) RTU | Westhampton, NY | 1 | 3 pressure |
| (1) RTU | Coney Island, NY | 1 | 3 pressure |
| (1) RTU | Virginia Beach, VA | 1 | 3 pressure |
| (1) RTU | Charleston, SC | 1 | 1 pressure |
| (2) RTU | St Mary's, FL | 2 | 1 pressure 1 acoustic |
| (2) RTU | Brunswick, GA | 2 | 1 pressure 1 acoustic |
| (7) DTU (3) RS | Ponce de Leon, FL | 10 | 12 pressure 9 acoustic 1 barometer |
| (1)RS (13) RTU | Los Angeles /Long Beach, CA | 11 | 10 pressure 1 pressure/current meter |
| Notes: RTU= automatically accessed remote transmission unit. DTU=automatically activated data transmission unit, see Howell (1996) for data and deployment details. RS= remote server. | | | |

INSTRUMENTATION AND SENSORS

Table 2 lists the type of sensors and instruments used and the coastal parameters monitored for recent projects. Single-pressure-sensor systems are deployed for nondirectional wave data and water level measurements. Three types of directional wave gauges are employed for monitoring:

- a. A bottom-deployed slope array with three pressure sensors that is cabled to shore.
- b. A bottom-deployed DWG-1 with three or more pressure sensors that may be cabled to shore or operate in an internal recording mode for approximately 13 months.

| Table 2 Instrumentation and Parameters Measured for Recent Projects | | |
|--|---|---|
| Project Site | Instrumentation | Primary Data |
| Chicago, IL | (1) 3-pressure-sensor NRT slope array | Directional wave spectra |
| Westhampton, NY | (1) 3-pressure-sensor NRT DWG-1 | Directional wave spectra |
| Coney Island, NY | (1) 3-pressure-sensor NRT DWG-1 (1) Internal recording directional wave gage | Directional wave spectra |
| Long Branch, NJ | (1) 3-pressure-sensor NRT DWG-1 | Directional wave spectra |
| Sandy Hook, NJ | (1) 3-pressure-sensor NRT DWG-1 | Directional wave spectra |
| Ocean City, MD | (2) 3-pressure-sensor NRT DWG-1 | Directional wave spectra |
| Ocean City, MD | (1) 3-pressure-sensor tide gauge with (1) on-shore single pressure sensor barometer | Tide data |
| Virginia Beach, VA | (1) 3-pressure-sensor NRT DWG-1 | Directional wave spectra |
| Charleston, SC | (1) Single pressure sensor ARTTES | Tide data |
| St Mary's, GA | (1) Single pressure sensor ARTTES and (1) acoustic water level sensor | Tide data |
| Brunswick, GA | (1) Single pressure sensor ARTTES and (1) acoustic water level sensor | Tide data |
| Ponce de Leon Inlet, FL | (3) 3-pressure sensor NRT DWG-1s (2) ADCPs (3) Single pressure sensors and (1) single pressure sensor barometer (1) Acoustic water level sensor | Directional wave spectra and tide data Current data Tide data Tide data |
| Pensacola, FL (RIBS) | (4) Single pressure sensors | Nondirectional wave spectra |
| Galveston Bay, TX | (2) Single pressure sensors | Wind waves Ship wakes Ship drawdown Tide data |
| Los Angeles and Long Beach Harbors, CA | (10) Single pressure sensors (1) PUV system | Nondirectional wave spectra and long Period wave data Directional wave spectra |
| Redondo, CA | (4) 3-pressure-sensor DWG-1 (5) PUV systems | Directional wave spectra |
| Yaquina, OR | (2) 4-pressure-sensor DWG-1 (4) Wave rider buoys | Directional wave spectra Nondirectional wave spectra |

- c. An electro-magnetic current meter (PUV) system with a single pressure sensor that may be cabled to shore or operate in an internal recording mode for approximately 6 months.

Acoustic doppler current profilers (ADCP) are deployed for measuring three-dimensional currents in and near tidal inlets. Single and multiple pressure sensors deployed offshore and single-pressure-sensor barometers mounted onshore are integrated to provide NRT tide data. Acoustic, above-surface sensors also are used to measure water level fluctuations. Single-pressure-sensor systems are used to measure long-period harbor waves and water levels in channels (ARTTES).

OPERATIONS AND DATA FLOW

The NRT wave gauges are cabled to an RTU. For sites where direct connections are impossible, data are transmitted by radio to a remote server (RS). Each RTU collects data hourly, starting at the beginning of every hour. Sampling frequency for waves is usually 1 Hz. A wave gauge RTU usually will hold about 3 days of data, in case of power loss. The computer at PMAB retrieves data by telephone and stores raw sample data in the PMAS sample database (McKinney and Howell 1996). For most sites, only every fourth data set is retrieved from the RTU by the computer. However, during times of high waves or at special request of the sponsor, every data set (one per hour) is retrieved. Termination of data retrieval initiates automated analysis of the wave data received. Analyzed data are stored in another PMAS database that contains only analysis results and information required to perform the analysis. Analysis is performed in accordance with PMAB's wave data analysis standard (Earle, McGehee, and Tubman 1995). Table 1 lists all remote sites, the number of systems found at each site, and the number of sensors associated with each system when fully operational. All these sites are monitored daily.

Tide gauges using the ARTTES are cabled to an RTU and a transmitter that broadcasts the data. ARTTES gauges at St Mary's, FL; Charleston, SC; Brunswick, GA; and Ponce de Leon, FL provide data in 6-min averages. Daily files are produced by a monitoring computer that captures the broadcast data and creates an ASCII listing of tidal averages. Files are quite small so several years of daily files may be stored in the monitoring computer. Sites are accessed by a script file that calls the monitoring computer and retrieves the previous day's file. ASCII files are stored in the PMAB computer. The controlled tide gauge and barometer at Ocean City collect 15-min records starting at the beginning of every hour. The sampling frequency is 1 Hz. Data are collected hourly by the automatic call-up that also accesses the wave data. Barometer and tide data are stored in the PMAS sample database. Pressure time series for both tide gauge and barometer are plotted daily along with wave gauge data for quality control monitoring.

QUALITY CONTROL

In addition to the numerical quality control procedures using onboard instruments, extensive manual quality control reviews are made daily (Table 3). Plots of pressure time series, directional and nondirectional wave spectra, actual and predicted tide data (for tide gauge

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| Table 3 |
| Quality Control and Reporting Data Products |
| Pressure Time series |
| Directional and nondirectional wave spectra plots |
| Actual and predicted tide data plots |
| U and V velocity time series plots |
| Wave height, period, and direction time series plots |
| ASCII files listing wave height, period, and direction |
| Ship wake plots |
| Ship drawdown data |

systems) and U and V velocity (for current meters) are produced daily for the most recent data acquisition times. Pressure time series plots show unedited data for all channels of each wave or tide gauge for the most recent data record collected. Spectral plots include the six most recent data records, the computed wave height, period, and direction (where applicable) as well as energy density and direction by frequency plots. Plots are printed and visually inspected. When wave heights meet the predetermined threshold, the database is set manually to collect data hourly. Return to 4 hr collection is also accomplished manually. All detected problems are referred to the appropriate specialist or point of contact at the PMAB. Time series plots showing wave height, wave period, and wave direction are also generated weekly for some of the sites (as requested by the sponsor or principal investigator).

MAINTENANCE AND BACKUPS

At the beginning of every month, wave data from the previous month are extracted from the databases and stored in separate monthly databases. At this time, all current and monthly databases and tide data files on-line are backed up to tape. Wave height, period, and direction time series plots are generated monthly for all the directional wave gauges. Production of these plots provides a simple method for finding data that vary from the norm. Spectral plots are produced for questionable data and the validity of data received is established. Invalid data are flagged as such in the database. ASCII files listing wave height, period, and direction also are produced and retained on-line. This procedure allows for fast access to recent data and a secure backup of historical data. Tide gauge and barometer data from Ocean City are extracted and an average of every 90 points is calculated to obtain 10 average readings per hour. These average readings are plotted for the month for both tide gauges and barometers along with a plot of the tide data minus barometric pressure. This provides a visual monthly check to verify that the sensors are producing valid and reasonable data.

OBTAINING DATA

PMAB maintains an Internet site at <http://sandbar.cerc.wes.army.mil>. Monthly files of significant wave height, wave period, and direction are maintained for most current and historical gauge sites. These data may be retrieved from the Internet site. Project information and location maps are also available. Future modifications to PMAB's Internet site include providing access to water level data, spectral data, and current data.

SUMMARY

Highest quality NRT monitoring of coastal engineering parameters is necessary in the design, maintenance, and operation of beach nourishment, coastal channel dredging, research, harbor design, and other CE coastal projects. A data acquisition, analysis, storage, and reporting system, PMAS, has been designed and developed to monitor existing CE projects and to allow addition of new projects and various coastal parameters. Hourly, daily, weekly, and annual products are provided to CE sponsors. Climatic summaries have been produced for 1993 (Sabol and McGehee 1995) and 1993 - 1995 (Sabol 1997).

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ADDITIONAL INFORMATION

For further information, contact:

Ms. Margaret Sabol
Prototype Measurement and Analysis Branch
Coastal Sediments and Engineering Division
Coastal and Hydraulics Laboratory

Voice: 601-634-2334

FAX: 601-634-3151

email: m.sabol@cerc.wes.army.mil